The Impact of Frustration on Problem Solving Performance

by

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Abstract

In line with anecdotal reports and the extant literature, it is apparent that mood has a significant role in cognitive performance. The affect of frustration on problem solving performance was investigated. Fifty three (27 female, 26 male) third form students were given either easy or difficult problems, to induce feelings of confidence or frustration. The results showed that the manipulation induced increased feelings of frustration and decreased feelings of confidence in both groups. As a result, there were no significant differences in performance between the two groups on subsequent problems. However there was a difference in performance levels on the two different types of tasks, with subjects scoring significantly higher on familiar format word problems, than on novel problem solving tasks. In addition, there was an interaction between problem type and order. Subjects who completed the word problems first scored significantly higher on these problems, than those who completed them second. There was no effect of order on the novel problems. Reasons are suggested for the failure of the mood manipulation, and suggestions are made for future research in this area

Introduction

A new mathematics curriculum has been implemented in New Zealand schools. One of its main aims appears to be to make mathematics more interesting for students, whilst at the same time providing the necessary skills to cope in a mathematical world. To this end the new emphasis is on practical and useful areas such as problem solving (Ministry of Education, 1992). It is intended that problem solving be introduced within every topic in the curriculum, thus giving students the ability to solve problems in all areas of mathematics.

Now that this initiative has been taken educators, need to consider what is the most effective method of teaching problem solving skills. To do this they will need to consider, which factors inhibit the development of these skills as well as which factors enhance them. There is a large collection of literature which attempts to deal with these problems. The main approaches to problem solving come from three areas: education, mathematics and psychology. To effectively answer questions concerning problem solving, work from all three areas needs to be assimilated.

My perspective is that of a mathematics teacher and psychology student. I am interested in untangling both theoretical and practical aspects concerning problem solving. My initial research question concerned why children appeared to be very poor at answering mathematical word problems. Several obvious answers spring to mind, such as, students can not read the problems, or they can not do the mathematical operations necessary to answer the problem. However most research shows that these are not the main reasons why students have difficulty solving such problems (Forsyth & Ansley, 1982; Gagné & Driscoll, 1988), although others disagree (Geary, 1993). Forsyth & Ansley (1982) suggest that students fail when it comes to processing the problem from written language into mathematical language. That is, they are unable to identify which variables they need and/or what type of mathematical operations to apply. This suggests that children have problems invoking the appropriate schema to deal with the problem. Thus I decided to investigate factors that may affect the use of problem solving schemas.

In searching for factors that may affect the process of invoking the correct schema to solve a problem, I found the research in the field of mathematics had shown that not only cognitive factors affected mathematics performance, but affective factors were also important. These included factors such as attitudes, self efficacy, motivation, confidence, and mood which were all shown to impact on mathematics performance (e.g. Bryan & Bryan, 1991; Elliot, 1990; Fennema & Sherman, 1977; Ginsberg & Asmussen, 1988; Hacket & Betz, 1989; Krutetskii, 1976). I decided to see how factors in this class may be related to problem solving performance. In particular I investigated the role of mood in problem solving performance.

In the following review of the literature I begin by looking at the evidence from the education and mathematics fields, which suggest how mood may contribute to learning in general. I then go on to consider some of the research from mathematics in this area. To develop some theory as to why this may be so, I examine research from cognitive psychology. Following this, the experimental evidence in the area of problem solving and mood is explored. I then report the various techniques that have been used to investigate mood effects, and outline a rationale for choosing a success/failure technique, and offer some predictions concerning these manipulations on problem solving performance.

Learning and Affect

What is affect?

There are three terms in this field of research that are often used interchangeably. They are affect, emotion, and mood. This being the case, it is a good idea to define how they will be used in this thesis. I use similar definitions to Morris (1989). Affect is used as the most general term to include factors such as attitudes, moods, and emotions. Mood is used as a more specific term to refer to pervasive feelings rather than intense specific emotional reactions. As suggested by Morris (1989) mood is more of a 'frame of mind', something that is always present whether we notice it or not. In contrast to moods, emotions are strong, usually conscious, reactions to outside stimuli.

Early conceptions of learning

Initial educational research suggested that there were good learners and there were poor learners. This approach implied that nothing could be done to improve achievement levels of poor learners. They would only be able to learn the simplest of things, so no effort was made to improve their learning outcomes. This idea changed after the introduction of a model by Carroll (1963), which suggested that there were fast learners and there were slow learners. That is all learners had the potential to learn the same concepts, but some people took longer than others. Carroll's model basically compared time spent to amount learned. This model implies that everyone has the potential to learn the same things, but some people will take longer than others.

Bloom (1976) challenged this model by suggesting that all students given 'favourable conditions' could learn the same things in the same amount of time. This was one of the first models to take into account the role of affective variables such as attitude to learning, confidence, and liking for the subject. He suggested that learning outcomes could be predicted from cognitive entry characteristics (ability or aptitude) and affective entry characteristics (attitudes, self-efficacy).

This model brought into focus the importance of factors other than cognitive ability in determining learning outcomes. Other more recent models of learning still stress the role of affective factors in learning (Fraser, Walberg, Welch, & Hattie, 1987; Martin & Briggs, 1986; Pekrun, 1992,). A brief overview of the literature from mathematics supports the importance of affective variables in learning.

Mathematics and affect.

Mathematics is a subject that many students find difficult and as a result of this, they often have strong feelings about it. This is probably the reason why so much research has been devoted to investigating the role of affect in mathematics performance. Most of the research in this area has concentrated on the role of attitudes in determining mathematics performance. Fennema (Fennema & Sherman, 1976; Fennema, Peterson, and Carpenter, 1987; Fennema, 1989) has been particularly active. She has shown that in some cases attitudes (as measured by scales she developed) can account for up to 45%

of the variance in mathematics performance (Fennema, 1976). Other studies have shown how self efficacy or confidence in doing well at mathematics may also predict mathematics performance (Hackett and Betz, 1989). Although these studies investigated the role of affective variables very few of them investigated the role of emotion or mood on mathematics learning outcomes.

There is only one major area of research investigating emotions specifically. That is the investigation of the role of anxiety in mathematics performance. Research has shown that some people suffer from what is known as mathematics anxiety, that is, they become anxious as a result of being faced with some mathematical problem. Most research shows that as a result of this, performance is lowered (Wigfield & Meece, 1988). However, this must only be in extreme cases, as other research shows that a certain level of anxiety or stress helps to improve performance (Revelle & Loftus, 1990). This suggests that maths anxiety is a dispositional disorder, and thus the role of anxiety in mathematics performance is dealt with further in this study.

Other researchers have suggested that emotions must play some role in mathematics learning. Krutetskii (1976) conducted a comprehensive study in the Soviet Union investigating factors that would affect mathematics learning and ability. Along with a host of cognitive variables he also took into consideration affective factors. He found that really 'gifted' mathematics students had strong positive emotional reactions to their achievements. Ginsberg & Asmussen (1988) use case studies to demonstrate the importance of emotional variables in mathematics performance. Other than these examples there are very few studies that specifically investigate the role of emotion in mathematics performance. Those that do are mostly case studies and as such offer little theoretical insight into the causes of the effects that are observed. To gain more understanding of how mood may affect performance, it is necessary to look at research from psychology.

Mood and cognition

Overview

Most of us would readily accept the idea that the way we are feeling can affect our thoughts. When we are in a cheerful mood we feel ready to tackle any problem, conversely when we are feeling down even the simplest task may appear overwhelming. Psychologists have tried to find out just how mood may affect our cognitive abilities. Most of this research has concentrated on memory tasks. Two main findings come from this research. One is the idea of mood congruence, that is we recall information that is similar to our mood, more easily than information that does not fit with our mood (Blaney, 1989). The second idea is related to state dependent learning. Researchers have shown that information is recalled more accurately if the mood at recall is the same as the mood at learning (Bower, 1981). However the evidence supporting this second theory is not as conclusive as that from the mood congruence studies.

Although these conclusions come from research on memory, rather than problem solving, they give a base from which to start investigating the possible effects of mood on problem solving. To begin the theories developed in the memory field may be useful for making predictions about the effect of mood on problem solving. In addition to this, one can investigate and then use the best of the methods developed by memory researchers.

In the following section I will describe some of the theories generated from research in the memory and mood literature.

Following on from this I will show how these theories are related to a theory developed to explain the link between mood and problem solving.

An associative model of emotion and memory

Associative networks

Bower's (1981) model was developed to explain results from research describing mood state-dependent learning and mood congruence. It is based on a network model of information processing described by Anderson and Bower (1973), and later modified and expanded by Anderson (1983). These models assume that information is stored in propositional networks.

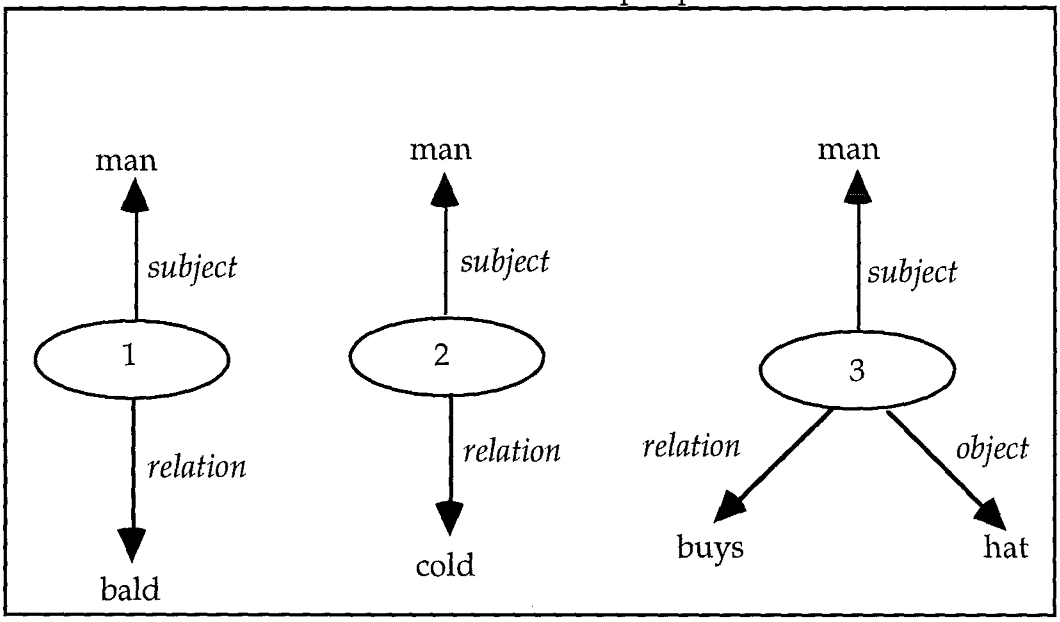

Figure 1: Example of Proposition Diagrams for the Sentence *"The bald man, who is cold buys a hat."*

Propositions are the smallest units of information that one can make true or false judgements about (Anderson, 1985). Large chunks of information are broken down into propositions and stored in memory. Take for example the following sentence:

The bald man, who is cold, buys a hat. This can be broken down into three propositions (Figure 1).

Propositions are the basic elements in a memory network. When one node in a network is activated excitation spreads to other related nodes in the network. Figure 2 shows how propositions may be linked in a network. In the example given I asked "What does the bald man do?"

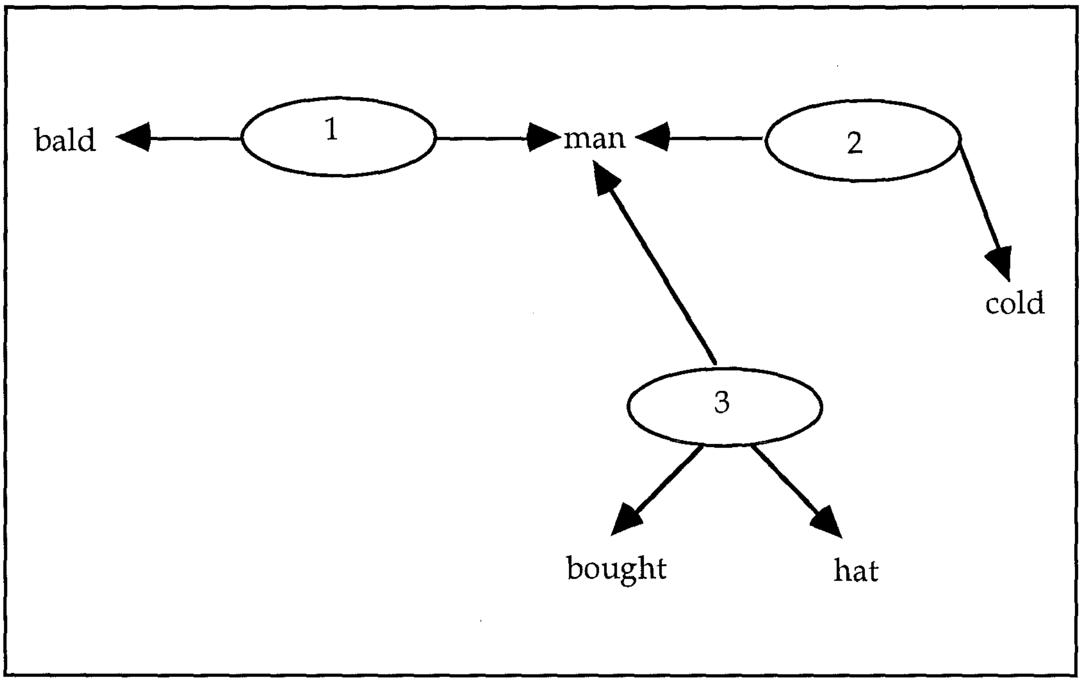

Figure 2: A Possible Network of Propositions for the Sentence *"The bald man, who is cold, bought a hat"*

This would activate proposition 1, and activation would then spread to proposition 3, so that the question could be answered. A certain level of activation is necessary before a node will become active, and activation decays as it spreads through the network. If there was no decay in activation the system would overload, because any input would eventually spread to activate the whole system.

Several assumptions based on experimental evidence (e.g. Collins & Quillian, 1969; Conrad, 1972; Weisberg, 1969) have been made about the way information is stored and retrieved from memory networks. The more often a fact about a concept is encountered the closer it will be stored to the concept. Following from this, the more often a fact about a concept is encountered, the stronger the link between the fact and the concept becomes. Thus, information about concepts that we encounter frequently will be retrieved from memory faster because the links are stronger and closer to the concept node, than facts that we encounter less frequently.

For complex concepts about which we have large chunks of information, the organisation of the network becomes more specialised. It is organised in a hierarchical order, with the more general facts about the concept at the top of the hierarchy and the specific facts at the bottom. These hierarchical sets of facts are called schema. They can be used to record information about broad concepts as well as events.

Bower's model

Bower's network theory of affect is based on these same assumptions. In addition to concept nodes and proposition nodes there are also special emotion nodes. These nodes differ from concept nodes in three ways. Firstly, it is postulated that some of these nodes are innate. This idea is validated by cross-cultural research, which shows that facial expressions for different emotions are equivalent across cultures (Gilligan &

Bower, 1983). The second difference is that when emotion nodes are activated, they get feedback from other nodes in the network, and hence can remain activated for some time. Finally, emotion nodes send out stronger messages than concept nodes.

As in general network theory, a propositionally encoded event becomes associated with other cognitive elements active at the time of learning. It is this idea that is used to explain mood state-dependent learning. If you are in a happy mood when you learn some new information this information will become associated with the 'happy' emotion node. Thus, when you are in a happy mood again you will be more likely to recall this information because your 'happy' node will be activated and hence send activation to the nodes previously associated with it. Conversely, if you are in a sad mood, the recall of the information will be inhibited because the sad node inhibits the happy node and hence inhibits any information associated with it.

Although this model of mood and memory has been criticised, non of the alternatives offer better explanations of the literature on mood and memory. In the next section this model is expanded to account for the effects of mood on problems solving.

Problem solving and mood

Problem solving: A definition

Before one can begin to discuss problem, solving a definition of just what we mean by a problem is required. Unlike some subjects, there seems to be a consensus within the literature about just what is meant by a problem. The definition given by Karl Dunker (1945, cited in Gilhooly, 1989, p.17) or variations of it are still the most popular and widely used:

"*A problem exists when a living organism has a goal, but does not know how its goal may be reached .* "

Using this definition, a simple mathematical equation for which you have an algorithm is not a true problem. However if you did not know how to go about solving the equation then it would be a problem. Thus problem solving is the process that an individual goes through to find the solution to a problem.

Marshall's theory of problem solving and mood

Marshall's (1989), theory, like Bower's (1981), is based on a network theory of cognition. Her theory was developed specifically to show how mood could be associated with problem solving. As a result her theory is based around schemas, because schemas are needed to solve problems(Marshall, 1989).

In Marshall's model, schemas are broken down into four basic components. The first component contains facts about the general instance in which a schema will be used. This is like a general description of the types of problem for which the schema may be used. For a mathematics problem this would include surface information about the type of problem. For example, is it an algebra problem? The second component contains the restrictions and conditions that must be met before the schema can be applied. This component is used to test how well the problem fits in with the initial description. Following on from the above example one of the conditions necessary for an algebra problem may be that it has to have letters as well as numbers in the problem. The third component is the planning mechanisms for implementing the schema. This includes the setting up of goals and sub-goals to solve the problem. In a mathematics problem this may include information about the order in which to perform various operations. The final component contains the actions and procedures used in the implementation of the schema. In the case of mathematics problems, this is where appropriate mathematics operations would be stored.

Marshall suggests that affective material can be encoded within these schema. Affect may be encoded at the same time as the initial schema or added to existing schema. In addition to this, affect may be encoded within any of the four schema components. For example a child may be learning how to solve algebra problems. In the first attempt at the problem the child makes a mistake, but can not see why. This may make the child angry, thus the schema for solving this type of problem may become weakly associated with anger. If the child continues to get these type of problems wrong for no obvious reason, the association between the anger node and the schema for algebra problems will be strengthened. Consequently, when the child comes across an algebra problem in the future, just the sight of such a problem may give him/her negative thoughts, and thus stop them from attempting to solve the problem.

It should be noted that this does not imply that every problem encountered has mood encoded with its schema. Mood will only be encoded with a problem schema if it is made particularly salient during the process of solving the problem.

Evidence linking mood and problem solving performance

Most of the studies that investigate the role of mood in problem solving show that positive mood enhances problem solving ability. However they do not tend to show how negative moods impact on problem solving performance. A review of the literature in this area shows that the issue is not as simple as it is portrayed to be. Like the research in the field of state-dependent learning, there is conflicting evidence about the role of negative moods. Even some of the studies manipulating positive mood are not as straight forward as they appear.

Take for instance an experimental study by Bryan and Bryan (1991) which showed that students put in positive moods performed better on mathematics problems than those in neutral moods. However, these researchers appear to have confounded their mood manipulation with attention. To put students in a positive mood they were taken aside individually, and given special attention. Those in the neutral condition were not given this same attention. This suggests a kind of "Hawthorne" effect may have been operating. That is the students' performance was affected simply because they had been singled out for attention, rather than because of any mood change.

A similar study by Greene & Noice (1988), involving eighth grade students, found that positive mood enhanced problem solving on two tasks. One of the tasks was Dunker's candle task. This task is often used in problem solving experiments. Subjects are given a box of drawing pins (thumb tacks), some matches, and a candle. They are asked to find a way to affix the candle on a wall using these materials. The solution is to empty the drawing pin box and pin it to the wall and place the candle in it. This may sound simple, but in order to solve this problem the subjects have to change their ideas about the function of the box of drawing pins. The second task was a word generation task. They also used a different mood manipulation, giving gifts and compliments to students in the positive mood group. In this case, both the neutral and positive groups received individual attention. However, no manipulation check was undertaken to establish that those given gifts and compliments did in fact become happier. Indeed other research has found that this type of manipulation was not effective in altering mood (Isen, Daubman, & Nowicki, 1987).

A more rigorous study by Kavanagh (1987), showed that subjects put in a happy mood performed significantly better on an anagram solving task than those in a sad mood. Mood was manipulated by getting subjects to recall sad or happy experiences from their past. This experiment was carefully constructed so that subjects were unaware that mood was important whilst solving the anagrams. As a result of this the mood generated in the early part of the experiment may have dissipated whilst the subjects were completing the anagrams.

A more recent study done by Isen, Daubman, & Nowicki (1987) compared six different mood manipulations. Subjects were either shown a funny film, a film about Nazi concentration camps, or a neutral maths film, given a gift (a second positive mood group), exercised (to increase their arousal level) or received no manipulation. The problem solving task in this experiment was once again Dunker's candle task. Results from this experiment showed that subjects who saw the comedy film performed significantly better than subjects in any other group. However as in Kavanagh's (1987) experiment, subjects who saw the negative film did no worse than those in the neutral, exercise or gift groups. Isen, Daubman & Nowicki are cautious about the interpretation of this result. To begin as mentioned, earlier their manipulation check showed that receiving a gift did not significantly alter subjects' moods. They also suggest that the negative film may have affected subjects moods in ways that they were unable to measure using their manipulation check. Their manipulation check did not investigate specific type of affect, but only general negative affect and general positive affect.

An article by Knapp & Clark (1991) investigating the effect of mood on subjects ability to solve resource dilemmas, found that sad and angry people were less successful at solving dilemmas than happy people. Like Kavanagh (1987), they led subjects to believe they were participating in two separate experiments. Their subjects read vignettes which had either neutral, happy, sad or anger inducing outcomes. To stop mood from dissipating over the course of the experiment subjects were led to believe that they would be asked questions about the vignettes after they had completed the problem solving task. A subsequent mood manipulation check only distinguished between sad and happy moods. Following this they participated in a game in which they had to figure out how to maximise their takings from a fictitious pool of fish. To do this, subjects had to figure out how many fish they could safely remove, while still leaving enough to propagate, and thus allow them to take more in their next turn. The mood manipulation in this experiment, (as I will show later) often leads to demand characteristics.

The final study that I examined in any depth investigated the relationship between depression and problem solving skills. Schwartz & Fish (1989), used the Beck depression inventory to group students into dysphoric and non-dysphoric groups. Like Kavanagh (1987) they used anagrams as their problem solving task. Their results showed that non-dysphoric subjects solved significantly more anagrams than dysphoric subjects. As I will show, the problem with this type of study is that rather than comparing the effects of fleeting moods, this type of experiment is comparing a more stable personality trait.

This brief review of the literature on problem solving and mood has shown as suggested, that there are still issues in need of resolution. All the studies described above have problems when close investigation is made of their methods. In addition to this only Bryan and Bryan (1992) directly investigate the relationship between mathematics problem solving and mood. This suggests further experimentation is necessary.

In the following section I describe some of the more popular mood induction techniques, and examine their failings.

I then outline the technique I have chosen to use. This is followed by the experimental rationale and hypotheses.

Techniques for studying mood and cognition

Individual Differences

Two different approaches have been employed in the study of mood and cognition. The first uses naturally occurring individual differences in mood. These types of studies predominantly recruit subjects with clinically assessed mood disorders, such as depression (Blaney, 1986). Such studies compare cognitive skills of depressed subjects with non-depressed subjects. Although this may sound like the ideal way to research such phenomena, there are several problems that may occur when interpreting results from this type of research. To begin with comparisons are being made between two different sub-populations, and it is possible a third or underlying variable, rather than mood is responsible for any observed differences (Morris, 1989).

Mood induction

The Velten procedure

Many different methods are used to change subjects' moods. Martin (1990) in her review of mood induction techniques lists 16 different methods. The most popular is the Velten procedure (Velten, 1968) or variations of it. In this procedure subjects are induced to be depressed or elated by reading self referent mood statements. A neutral condition involves reading neutral statements. Subjects are asked to adopt a mood suggested by the statements and keep this mood whilst they complete some cognitive task. This procedure has also been extended to induce anxiety. Several criticisms have been made of the method. The most obvious of these is that the procedure is prone to demand characteristics (Buchwald, Strack, & Coyne, 1981). That is the subjects will behave as though they are in the mood suggested just to please the experimenter. However, other researchers have defended the Velten procedure claiming that *"...Velten-induced reactions are probably too subtle to have been deliberately faked "* (Berkowitz & Tróccoli, 1986, p. 337). Even if demand characteristics are not present, there is another problem with the Velten procedure. The possibility exists that the results observed (especially in mood congruent studies) are due to priming effects rather than mood. That is, effects may occur because subjects have read mood statements and this has primed them to recall further information related to those statements.

Hypnosis

Another method that has been popular is hypnosis. This was used extensively by Bower and associates (Bower, 1981, Gilligan & Bower, 1983). Hypnotically suggestible subjects are hypnotised and asked to recall a memory relevant to a particular mood. They are then asked to forget about the particular instance, but stay in the mood that has been induced. This method has similar problems with demand characteristics as the Velten procedure. Additionally, since only a small proportion of people can be hypnotised (Morris, 1989). findings may not be generalisable to the broader population

Success/failure technique

In experiments using the success/failure method subjects are somehow lead to believe that they have succeeded or failed at a particular task. It is presumed that subjects that succeed at a task will be put in a positive mood, whilst those who fail will be put in a negative mood. Research from the learned helplessness domain supports this notion (Dor-Shav & Mikulincer, 1989; Mikulincer, 1988; Sedek, & Kofta, 1990). It has been demonstrated that subjects who fail constantly, tend to have more negative moods than control subjects.

The advantage of this method over the Velten procedure and hypnosis is that it is not necessary for subjects to know that mood is an important variable in the study. Another consideration is that success and failure occur in real world situations. Thus, this induction should reflect real world emotions with more accuracy than other methods. The most common criticism of this method is that researchers simply assume that success and failure do in fact manipulate mood in the direction that they desire, without checking that mood has in fact been manipulated (Martin, 1990). The other major problem is the limitation of the type of moods that can be induced. Even taking these criticisms into account, success/failure manipulations still appear to be one of the most useful ways to manipulate mood, and it is readily applicable in a problem solving context. Hence it is the method employed in this thesis

Experiment rationale

As stated earlier, research investigating the role of negative mood and problem solving needs clarification. Most of the published studies consider only depressed or sad moods. Generalisations are often made from these experiments to suggest negative mood will impair performance, despite the fact that moods such as anger and frustration are rarely investigated.

Frustration and Problem solving

Causes of and reactions to frustration

My experience as a mathematics teacher suggests that frustration is a common feeling expressed by students when they are unable to solve problems. This reaction to novel types of mathematics problems, has also been observed by McLeod (1989). Glass & Singer, (1972, cited in Roseman, Spinder, & Jose, 1990) found that people became frustrated by unsolvable tasks. Thus, if a child is given a new problem that he/she expects to be able to solve, but can not solve, they become frustrated.

McLeod (1989), suggested that when students became frustrated they often stopped trying to solve the problem. A theory of creative problem solving suggests that when people become frustrated by a problem, three out of four times they will simply give up trying to solve the problem (Sapp, 1992).

Integrating schema theory and frustration

These ideas can be integrated with Marshall's theory of emotion and problem solving to explain how frustration may impact on problem solving performance. The following example illustrates the connection:

A student is presented some new class of problems (PC1), that they expect to be able to solve. They try to solve some of the problems, but fail. As they expected to be able to solve these problems, they feel frustrated. Thus, frustration becomes linked to their schema for PC1. It should also be noted that, as they could not solve these problems their schema for PC1 will only be superficial.

The student is then presented with some more new problems (PC2), which on the surface appear very similar to PC1. As the student has a weak schema for PC1, they can not distinguish PC2 from PC1. Thus the presentation of PC2 will keep the schema for PC1 activated. Consequently, the frustration node will remain activated. This may stop the student from investigating PC2 any further, as they believe these are the same type frustrating problems as PC1.

If the second set of problems were familiar problems (PC3), a different outcome is predicted. As PC3 are familiar, it would be expected that the student would have a well developed schema for solving these problems. Therefore, although the student is feeling frustrated by PC1, when they encounter PC3, a different schema will be activated. Once this new schema has been activated feedback to the frustration node should stop, and hence the feeling of frustration should dissipate. Assuming the schema for PC3 is not associated with frustration the students should have no problem trying to solve PC3.

Frustration and confidence

Studies investigating the effects mood on problem solving performance have found self-efficacy is increased by positive mood manipulations and decreased by negative mood manipulations. It has been suggested that the effects of mood are mediated by self-efficacy (Kavanagh, 1987). Thus, in this study feelings of confidence, as well as frustration will be measured.

Hypotheses:

1. Students who attempt problems that they can not solve will report higher levels of frustration and lower levels of confidence than students who attempt who attempt solvable problems.

2. Students who have become frustrated attempting PC1 problems will perform at a lower level on PC2 problems than children who have not experienced frustration with PC1 problems.

3. Students who have become frustrated attempting PC1 problems will perform at a lower level on PC2 problems, but their performance on PC3 problems will not be affected.

Method

Pilot study

Before the main study was completed, a pilot study was undertaken to establish the following:

1. The effectiveness of the mood manipulation.
2. The reliability of the affect checklist.
3. The difficulty levels of the problem solving tasks.

This study was undertaken at a school with a similar socio-economic catchment as the school in the main study. Students in an average ability class voluntarily participated in the study during class time. The students normal mathematics teacher ran the experiment.

Mood manipulation

Students were given either impossible problems or solvable problems to manipulate their mood. These problems were based on those used by Sedek and Kofta (1990). The type of manipulation proved to be ineffective. In the main study mood was manipulated by administering difficult, but solvable problems.

Affect checklist

The affect check list was based on the Mood affect check list developed by Nowlis (1974). Two sub-scales were developed to measure confidence and frustration. Reliability checks showed that the internal reliability levels of both these scales were acceptable. (happy, $\alpha = 0.73$; frustration $\alpha = 0.65$).

Problem solving tasks

Two problem solving tasks were used in this study, a word problem solving task (PC3) and a novel problem solving task (PC2). (These tasks are described in detail later). Subjects had high scores on PC3 (M = 81%). Scores on the easy PC2 problems were also high (M = 72.5 %), whilst scores on the difficult PC2 problems were low (M = 10.5 %).

Main study

Subjects

The subjects were 53 third form secondary school students (27 female and 26 male). Their ages ranged from 13-14 years with a mean age of 13.7 years. They were in average ability classes, from a Christchurch school which is in a low socio-economic catchment area The students voluntarily participated in the study during class time.

Design

As noted in the introduction a success/failure technique was used to manipulate mood. This was done using a problem solving task. Half of the subjects were given easy problems (success condition), whilst the others were given difficult problems (failure condition).

After the mood manipulation subjects did two different mathematics tasks: A novel problem solving task (PC2), and a familiar format word problem solving task (PC3). This was a within group manipulation with all subjects doing both tasks. To account for any order effect half of the subjects did PC2 first whilst the others did PC3. Figure 3 gives a diagrammatic representation of the experimental design.

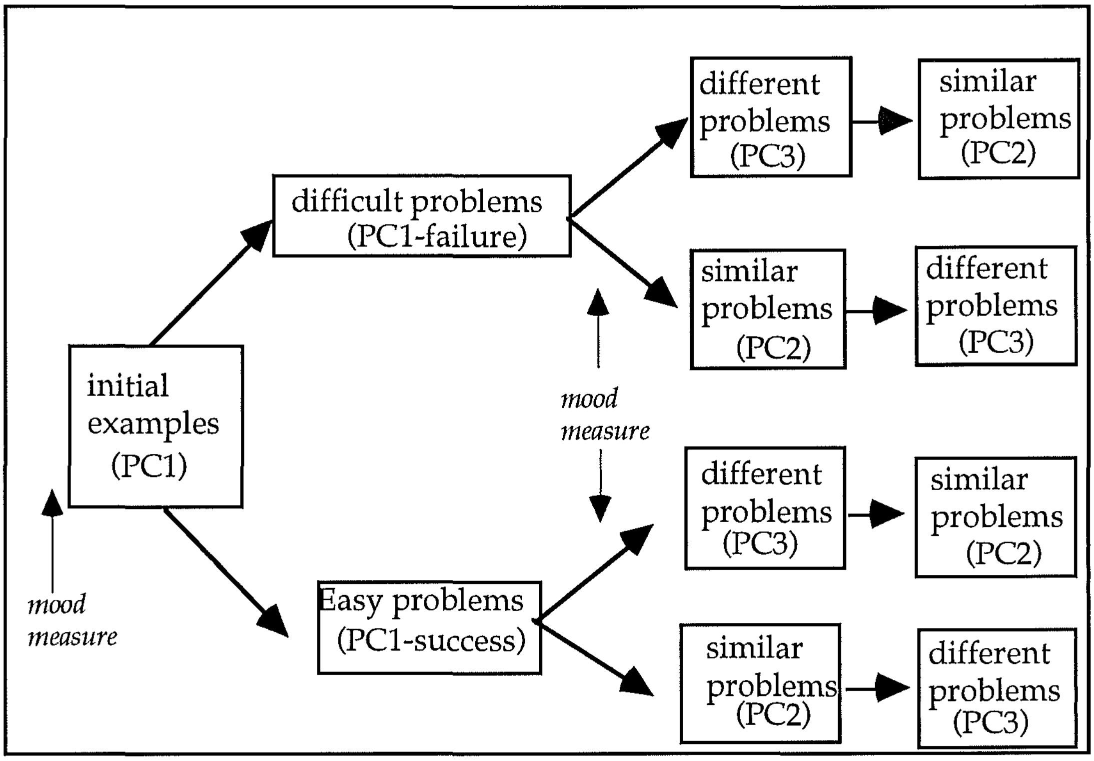

Figure 3: A Diagrammatic Representation of the Experiment Design.

Subjects were randomly assigned to one of four groups as shown in Table 1.

Table 1: Numbers of Subjects Assigned to Each of the Four Groups, Broken Down by Sex

		MOOD MANIPULATION	
		Success	Failure
ORDER	PC3/PC2	16 (11 F, 5 M)	14 (6 F, 8 M)
	PC2/PC3	11 (5 F, 6 M)	12 (6 F, 6 M)

F= Female,

M= Male

Materials

Affect checklist

The format for the checklist was based on the Mood Adjective Checklist (Nowlis, 1970). Two sub-scales to measure affect were developed for use in the present study. The first was used to measure frustration. This scale consisted of four emotion words: *"frustrated"*, *"angry"*, *"hopeless"* and *"irritated"*. These words were chosen because they appeared to be the most closely related to the concept of frustration (Davitz, 1969). The second was used to measure confidence. This also consisted of four words: *"happy"*, *"confident"*, *"bright"* and *"satisfied"*. Once again these words appeared to be linked to the concept of confidence (Davitz, 1969). These words were embedded in a scale consisting of sixteen words in total. Half of the words described positive moods and the other half described negative words (Appendix I). As the checklists were administered twice (immediately before and directly after the mood manipulation), the order of the words on the second checklist was changed to minimise the possibility of subjects copying responses from the first scale on to the second scale. Subjects were asked to rate how they were feeling on a 1 (not at all) to 5 (very) scale for each word. Thus for each scale the minimum score was four and the maximum score was twenty.

Problem solving tests

The two problem solving tests were made up of questions taken from a problem solving textbook designed for use in teaching elementary problem solving skills (O'Brien, 1980).

These tasks were chosen because no reading was necessary after the initial instructions had been understood. This ensured that problem solving ability was being tested rather than reading level or comprehension. In addition only the basic mathematical operations of addition, subtraction multiplication and division were necessary to solve the problems. Thus no complex operations needed to be known to solve the problems. In addition, each problem was broken down into parts. Each part builds on the previous one, guiding the student to the final answer.

O'Brien gave difficulty ratings for each problem. These ratings were used to sort problems into the easy and difficult test categories. A pilot study confirmed these difficulty levels, with subjects scoring much higher on the easy problems than the difficult problems.

Mood manipulation problems

In the mood manipulation problems (PC1) groups of pairs of numbers were given as examples of members of a named category. In each case the second number in the pair could be generated by doing some mathematical operation to the first number. For each category the operation was the same for all the pairs that were members. For example the following sets of pairs all belong to the category Piniops:

$15 \rightarrow 11 \qquad 8 \rightarrow 4 \qquad 21 \rightarrow 17 \qquad 39 \rightarrow 35$

In each case the second number may be obtained by subtracting four from the first number. Subjects were given several examples of the category as above. There were three parts to each problem. For part one subjects had to generate the second number given the first number. For part two they had to generate their own pairs as examples of the category, and for part three they had to state the rule for the category. Two separate tests were developed for these mood manipulation problems. One test was made up of problems rated as easy and the other was made up of problems rated as difficult (Appendix II). Subjects completed either the easy or the difficult set of problems;. For both tests, two practice examples were given, followed by four test problems. Each problem was worth nine marks, (6 for part one, 2 for part two, and 1 for part three). Thus there were a total of 36 marks to be gained. These marks were converted to percentages so that they could be compared to scores on the other tests.

Test Problems

These problems (PC2) were superficially similar to PC1 problems, but a different strategy was required for solution. PC2 problems gave both confirmatory and disconfirmatory examples of members of each category. Rather than pairs of numbers being presented two groups of numbers were presented. The first set of numbers consisted of examples which were members of the stated category. The second set comprised non- members.

For example :

10, 790, 340, 0, 20 are members of the category Jetabs

145, 33, 11, 402, 75 are not members of the category Jetabs.

In this example a number must end in zero to be a member of the category Jetabs. Once again there were three parts to each problem. For part one subjects had to pick category members out of a list of four numbers. Part two, as above, required subjects to give their own examples of members of the category, and for part three subjects wrote down the rule for the category.

Once again two examples were given to begin, but this time there were six test problems (Appendix III). The difficulty level of these problems was varied with half the problems rated as difficult and half easy (O'Brien, 1980). Each problem was scored out of ten (6 for part one, 3 for part two, and 1 for part three). Thus the test was out of a total of 60 marks. Once again scores were transformed into percentages so that they could be compared with other tests.

Word Problems

The problems chosen for this task was based on questions from the Progressive Achievement Test for Mathematics (P.A.T-M) used in New Zealand schools. Two criteria were used to select questions. The questions had to be phrased in word form rather than directly as mathematical equations. For example questions such as:

> Megan wants to buy a microwave oven costing \$675. She can pay \$60 per month for 1 year or the whole \$675 now. How much does she save by paying now?

were used rather than:

$$675 - (12 \times 60) = ?$$

To further reduce the number of questions and ensure that they were not too difficult for average students, only questions on which at least forty percent of students had scored correctly during norming of the original test were used (Reid & Hughes, 1974). Following this the questions were sorted so that half of these questions involved computations while the others were non-computational . This was done to check that the test was not only measuring subjects' ability to do calculations, but also their ability to process the problems and implement the necessary mathematics operations needed to solve the problems (Forsyth & Ansley, 1982). There were a total often problems. Questions 1, 2, 5, 9, and 10 involved computations, whilst questions 3, 4, 6, 7, and 8 were non-computational(Appendix IV). To stop students recognising any of the P.A.T.-M. items the wording of each question was changed without altering the solution processes. The test was scored out of ten, one mark per question. Scores were converted to percentages so that they could be compared with the other tests.

Procedure

Students were asked to participate in this research during their normal mathematics class. They were told that their results would be anonymous and hence would not count towards their mathematics assessment. After students had agreed to participate, the tasks were randomly distributed in booklet format, with a separate answer booklet. Students were asked to fill out the cover of their answer booklet, giving their sex, age, class and school. They were told that the tasks were designed to investigate how people felt whilst solving different types of mathematics problems. Thus they would be completing some emotion scales as well as several mathematical problem solving tasks. They were then given the following instructions before they began the test:

"There are two emotion scales and three test sections to be completed. Please try your best to answer all the questions, but if you get stuck on a question go on to the next question. You will have fifteen minutes to complete the first set of questions. If you finish these questions before the time is up please follow the instructions given at the bottom of the page and go on to complete the rest of the test. Apart from this first set of questions you will have as long as you like to finish the test. I will tell you when your time is up on the first set of questions, you must then go on to the rest of the test and you can not come back to this first set of questions. Does anyone have any questions before we begin?"

Questions were fielded and then students were told to begin. They started by filling out the first affect checklist. They then went on to complete the mood manipulation tasks. Students worked individually in silence. After fifteen minutes students were told to finish this first section and fill out the second affect check list. Having completed this they were told to carry on with the remaining tasks. This fifteen minute level was set so that subjects attempting the difficult questions would not spend too long trying to complete this section. Most subjects completing the easy questions took approximately fifteen minutes to complete this section. The answer sheets for the mood manipulation task were a different colour from the others in the booklet so that it could be noted at a glance if students tried to return to this section. No students were seen trying to return to the first section. After all the students had completed the test, they were debriefed and thanked for their time. It was explained that half of them had done very difficult questions to begin, whilst the other had done relatively easy questions. It was expected that those who did the difficult questions would become frustrated, and as a result of this perform poorly on the remainder of the tasks. Any students who felt upset by the experiment were encouraged to contact their teacher.

Results

Scale reliability and validity

Preliminary data analysis consisted of testing the internal reliability of the confidence and frustration scales using Cronbach's alpha. Both scales proved to be reliable: confidence (·89) and frustration (·79).

To examine the validity of the scales, they were intercorrelated. As expected they were not correlated ($r = -\cdot 20$, $p > 0\cdot 19$), showing that they were measuring different concepts.

Manipulation check

As expected it was found that the subjects in the success condition for the mood manipulation problems, scored higher on these problems (M= 35·8%) than those in the failure condition (M = 4·8%). The distribution of these variables was not normal, thus a t-test could not be used to compare the means. To determine whether there was a difference between the two groups the data were put into two categories: those scoring zero and those scoring more than zero as shown in Table 2. A Fisher-Irwin exact test[1] revealed there was a significant difference in numbers in each category ($\alpha = 0.0006$)..

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[1] This test was chosen due to the small cell sizes (two cells with < 10), which may have led to the possibility of a type I error if a chi square test was used(Bhattacharyya & Johnson, 1977).

Table 2: Contingency Table Showing Number of Subjects in Each Category

Mood Manipulation	Scores on mood manipulation problems: 0	≥ 1
Success	6	21
Failure	18	8

<u>Affect checklist scores</u>

A further check was made to see whether this manipulation altered the moods of subjects. As can be seen in Table 3, overall scores on frustration were low, both before and after the manipulation.

Table 3: Scores on Frustration Checklist by Mood Manipulation

	Frustration scores	
Mood manipulation	Pre-manipulation	Post-manipulation
Success	5·5	7·1
Failure	6·4	8·4
Average scores	6·0	7·8

A 2(Mood manipulation: success, failure) X 2(frustration score: pre-manipulation, post-manipulation) analysis of variance showed that there was no interaction between mood manipulation and frustration scores. However a significant main effect was found. Subjects had higher frustration scores after the mood manipulation regardless of whether they were in the success or failure condition, $F(1, 45) = 9{\cdot}09$, $P \leq 0{\cdot}004$.

Analyses using the confidence scales gave similar results. There was no interaction between mood manipulation and confidence scores. As can be seen in Table 4 both groups showed drops in confidence scores regardless of which type of problems they had attempted. An analysis of variance showed that these scores were significantly different, $F(1, 46)=9{\cdot}57$, $P \leq 0{\cdot}003$.

Table 4: Scores on Confidence Checklist by Mood Manipulation

	Confidence scores	
Mood manipulation	Pre-manipulation	Post-manipulation
Success	11·9	10·8
Failure	12·3	10·0
Average scores	12·1	10·4

Main data analyses

Preliminary analyses

Initial analyses showed there were no sex differences on any of the tests. Thus this factor was not taken into account in any further analyses. In addition to this, no differences were found between scores on the computational and non-computational questions in the multi-choice section, so these were treated as one variable in the analyses. An initial investigation of PC2 scores showed that a floor effect had occurred in the difficult problems, with 60% of subjects scoring zero, and a mean score of 7·8%. Thus these problems were not included in the analysis.

Effects of mood manipulation on test scores

A 2(Mood manipulation: success, failure) X 2(Order: PC3/PC2, PC2/PC3) X 2(Test type: PC3, PC2) MANOVA, with repeated measures on the last factor was undertaken.
The results of this showed that contrary to the main hypotheses there was no main effect for mood manipulation ($F(1, 49)= 0.1$, $p> 0.7$). There was also no interaction between mood manipulation and test type ($F(1, 49)=.27$, $p> 0.6$).

Effects of test type on scores

However as can be seen in table 5, there was a difference in scores between the two types of tests. Subjects scored significantly higher on the multiple choice test than on the problem solving tests, $F(1, 51)=4{\cdot}57$, $P \leq 0{\cdot}04$.

Table 5: Scores on Problem Solving and Multiple Choice Tests

	Mood Manipulation			
	Success		Failure	
	Order			
Problems	PC3/PC2	PC2/PC3	PC3/PC2	PC2/PC3
PC3	57.5%	28.2%	55.7%	40.0%
PC2	34.0%	37.0%	35.5%	35.6%

<u>Order Effects</u>

There was no main effect for order, however there was an interaction effect, between order and test type ($F(1, 49)=6.75$, $P \leq 0{\cdot}01$). A tukey test revealed that there was an order effect for PC3 but not for PC2 ($q_r = 5.4$) (figure x).

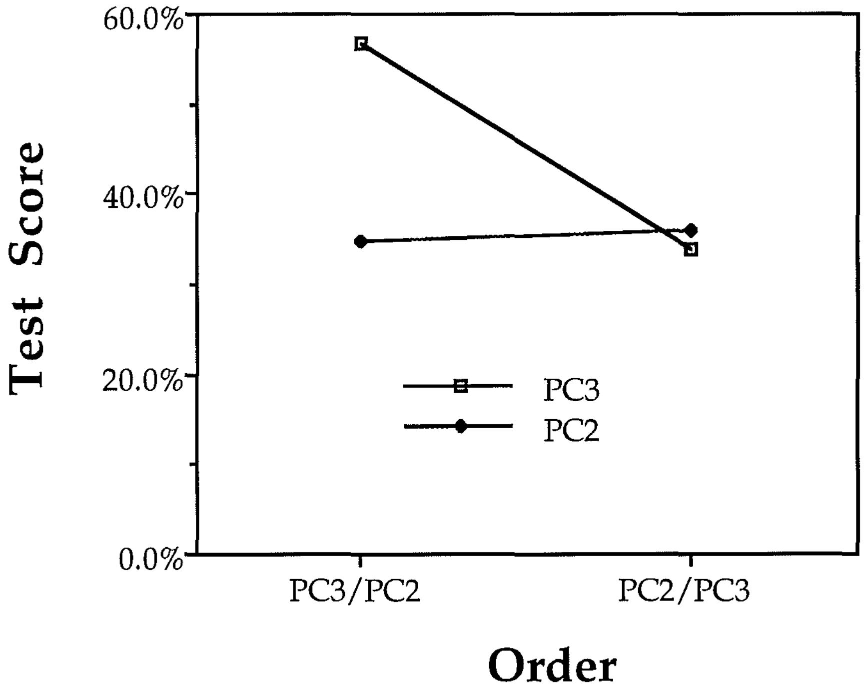

Figure 4: The interaction between order and task type

The analyses revealed there were no other effects.

Discussion

Overview

In the following discussion I will consider the results in relation to the hypotheses proposed earlier. This is followed by an evaluation of the method. I also suggest some possible improvements to the method. Recommendations are then made for future research in the mood and problem solving field. Finally, a brief summary of the implications of this type of research in the field of mathematics education is considered.

The effect of success/failure on mood

The results of the manipulation check indicated that difficulty level of initial problems had no differential effect on expressed frustration or confidence. Both groups showed similar increased levels of frustration and similar decreased levels of confidence. An examination of the scores on the mood manipulation problems may offer some explanation for the similarity of moods. In contrast to a pilot group who had high scores on the success questions (M= 72.5%), and low scores on the difficult questions (M=10.5%), both groups in the present experiment tended to have low scores ($M_{(success)}$=35.8%, $M_{(failure)}$=4.8%). Subjects who were only getting one in three questions correct were more likely to experience feelings of failure, than success. Thus, not only did the "failure" group feel frustrated, but so too did the "success" group.

Mood and problem solving performance

The results show that both the success group and the failure group scored equally well on the problem solving tasks. This implies that mood did not affect performance. However as the manipulation did not induce different moods in the two groups, no conclusions can be made about the effect of mood. In fact both groups would be expected to have similar levels of performance on the problems, given both groups appeared to have experienced similar levels of frustration.

Mood and task type

Both groups of subjects performed significantly better on the PC3 questions than on the PC2 questions. This result may offer partial support for the third hypothesis. Based on Marshall's theory of mood and problem solving it was predicted that the frustrated group's performance on PC3 problems would not be affected by the mood manipulation. However, as both groups were frustrated it would be predicted that their performance on PC2 problems would be lowered. It would be expected that scores on PC3 would not be affected by frustration, and as a result would be higher than subjects scores on PC2. This is only speculative, as there is no way of knowing how subjects would have performed on these tests had they not been frustrated.

In addition, there are much more obvious reasons that could account for differences in scores on the two tests. Students would have had much more practise at answering questions like those in the PC3 test. This is because these are the type of word questions that students generally encounter in the mathematics classroom. This suggests they should have more highly developed schemas for this type of problem (Anderson, 1983; Marshall, 1989). Consequently links between the concepts in the schema should have been stronger, and therefore more readily accessed and implemented.

Order effects

Although no main effect was found for order of presentation of tasks, there was an interaction between order and task type. Subjects who completed the PC3 first had significantly higher scores than those who completed it after the PC2 task. However order had no effect on PC2 scores. Although this pattern of results was not predicted, it may be possible to explain them with reference to research in the field of learned helplessness.

Subjects who completed the PC3 problems first achieved relatively high scores on this task. This suggests that they should not have become more frustrated by the task. As a result it would be expected that their scores on the following PC2 task should not have been affected. Thus, it would be predicted subjects who completed the PC2 task after the PC3 task would perform at much the same level as those who completed the task first. PC2 problems were difficult, and as a result of this subjects may have experienced further frustration whilst completing these problems. It appears, this may have affected their scores on the subsequent PC3 problems. Although, it was predicted that scores on the PC3 task would not be affected by failure on previous problems, there is evidence from the field of learned helplessness that might offer some explanation for the effect observed.

It has been shown that learned helplessness can occur when people Initial exposure to unsolvable tasks usually elicits frustration. However, continued exposure to this type of task may elicit feelings of depression. People become convinced that nothing they do will affect their ability to solve future problems (Dor-Shav & Mikulincer, 1989; Sedek & Kofta, 1990). As a result of this they perform poorly on subsequent tasks, regardless of task content (Sedek & Kofta, 1990). This may have occurred here.

These ideas are at best speculative, as no mood measures were made between the PC2 and PC3 tasks. Thus, it is not possible to demonstrate that subjects did become depressed.

Critique of the experimental design.

Efficacy of the mood manipulation

As noted in the results section, overall frustration scores were low. Thus although the manipulation made students feel more frustrated, overall feelings of frustration were still low. There are several factors that could account for this. Students were not given specific feedback concerning their scores for this section. It was assumed that they would have a good idea of how well they had done without feedback. It is possible that the manipulation may have had more effect had students been given their scores on the initial section.

Mood carry over

It was suggested that frustration would dissipate once the schema for the frustrating problems was no longer activated. Thus frustration on one set of problems would not effect performance on the following set of problems. However, subjects may still have been feeling frustrated when they initially approached the next set of problems. This could have affected the way they interpreted the problems, and thus affected their performance on the problems. One way to stop this from occurring would have been to give subjects simple distracter tasks between the different types of problems. This would stop subjects from thinking about the previous task, and thus any mood that had been aroused should dissipate.

Affect Checklist.

The affect checklist consisted of only two sub-scales; frustration and confidence. As a result, other moods that might have been affected by the manipulation will have gone undetected. For example, it has been shown that whilst subjects initially feel frustrated by failure on a task, if they continue to fail, they may start to feel depressed (Mikulincer, 1989).

Problem solving tasks

These tasks were chosen because they were unfamiliar to students. As a result it was hard to determine how difficult they would be for students. Although a pilot study using subjects from what was considered a comparable school, indicated that the problems chosen should have been solvable by third form students, those who participated in the study clearly found the problems too difficult.

Suggestions for future research

Frustration and problem solving

In any future research that investigates the role of frustration in problem solving performance, it will be necessary to develop a reliable method of manipulating frustration. Although the success/failure technique used in this research did not affect mood differentially, this type of manipulation is probably the most relevant to use in this area. If the ability level of subjects is clearly established and feedback is given about success or failure, this type of manipulation will probably be successful.

Mood and Problem solving

Most of the research in this area simply compares the effects of positive and negative moods. The failure to differentiate between different types of positive and negative moods may account for the variation in research outcomes in this area, especially with respect to negative moods. For example, depression, anxiety and anger may all have quite different types of effects on problem solving performance. An experiment that compared the different types of mood would be more informative than the piecemeal studies that have been done in the past.

Theory

One thing that is lacking in this area in a comprehensive theory that will explain all the results from the mood and memory research. Whilst Bower's model is a useful frame within which to approach this type of research, it is now somewhat dated in light of developments in the field of cognitive science. However, researchers in the field of cognitive science have largely ignored the role of mood in cognition, a factor lamented by Newell, Rosenbloom, and Laird (1989).

Implications of mood research for mathematics education

It is only relatively recently that the impact of affective factors on mathematics performance have been considered (Ginsberg & Asmussen, 1988). The role of factors such as self-efficacy in mathematics performance have been firmly established (Fennema & Sherman, 1977; Hacket & Betz, 1989). That is, students' confidence in their ability to solve problems is one of the best predictors of performance. Research on mood and problem solving has suggested that self-efficacy may be linked to mood (Kavanagh, 1987; Kavanagh & Bower, 1985). It has been suggested that subjects who feel positive, may spend longer trying to solve problems. This in turn increases their problem solving skills and confidence about solving problems. Thus, they are more likely to approach future problems with a more positive outlook. This suggests that if students are initially given problems that they can succeed in solving, they will feel more positive about trying to solve more difficult problems later. The implication is to encourage students to have a positive approach to problem solving, and that the initial problems that they are presented need to be chosen carefully. These initial problems should be enjoyable and challenging, but not overly difficult. Some problems can be used successfully with students at different levels (e.g. Holten, 1993). More of these type of problems need to be developed to ensure that every student is working at the appropriate level.

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Appendix 1: Affect Checklists

1. Pre-mood Manipulation Check
2. Post-mood Manipulation Check

Pre-mood Manipulation Check

Below are a list of words that describe feelings. Read the words carefully. For **each** word, tick the box that best describes **how you feel NOW.**

	not at all	a little bit	moderately	quite a bit	very
Alert					
Uptight					
Bright					
Irritated					
Satisfied					
Proud					
Happy					
Frustrated					
Confident					
Nervous					
Sad					
Hopeless					
Friendly					
Cheerful					
Angry					
Worried					

Post-mood Manipulation Check

Below are a list of words that describe feelings. Read the words carefully. For **each** word, tick the box that best describes **how you feel NOW.**

	not at all	a little bit	moderately	quite a bit	very
Proud					
Uptight					
Alert					
Frustrated					
Confident					
Bright					
Friendly					
Irritated					
Happy					
Satisfied					
Hopeless					
Worried					
Nervous					
Cheerful					
Angry					
Sad					

Appendix 2: Mood Manipulation Problems

1.Examples

2. Success Problems

3. Answer Sheet 1 for Success Problems

4. Failure Problems

5. Answer Sheet 1 for Failure Problems

6. Answers to Examples for PC1 and PC2

Examples

Mollywobbles:

These problems are called Mollywobbles. Mollywobbles are **pairs** of numbers with the same relationship between them.

e.g. 2 4

3 6 These pairs of numbers are related because for

4 8 each one if you multiply the first number of the

5 10 pair by 2, you will get the second number.

Below are two examples for you to try. You have to figure our how the pairs of numbers are related. Do not write the answers on the question sheet. Turn to the Mollywobbles answer sheet in your answer booklet.

1. Piniops

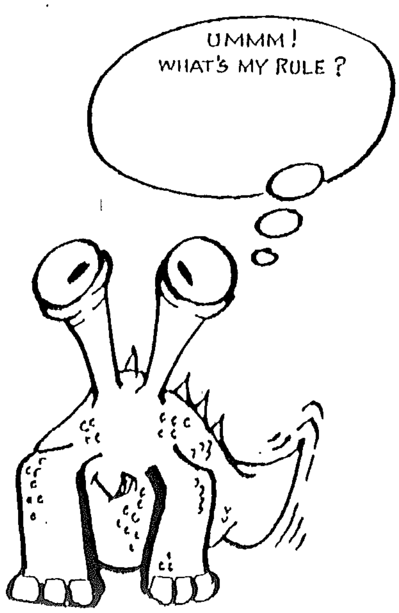
All of these are pinlops.

15 → 11 8 → 4

21 → 17 39 → 35

Make pinlops of these:

1. 28 →
2. 17 →
3. 92 →
4. 11 →
5. 14 →
6. 56 →



2. Googologs

All of these are googologs.

3 → 9 9 → 27 4 → 12 80 → 240

Make googologs out of these:

1. 10 →
2. 17 →
3. 5 →
4. 19 →
5. 20 →
6. 51 →

Success Problems

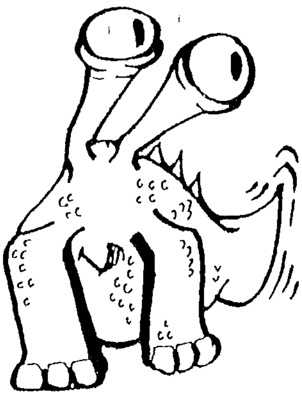
3. Willids

All of these are willids.

1 → 8
6 → 48
11 → 88
19 → 152

Make willids out of these:

1. 15 →
2. 2 →
3. 16 →
4. 30 →
5. 100 →
6. 106 →



4. Calins

All of these are calins.

10 → 2
13 → 5
8 → 0
100 → 92

Make calins out of these:

1. 20 →
2. 44 →
3. 19 →
4. 31 →
5. 12 →
6. 45 →

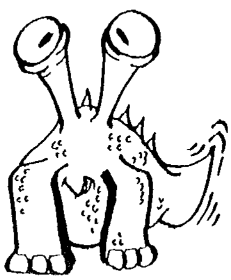
5. Homins

All of these are homins.

1 → 1
2 → 4
10 → 100
7 → 49

Make homins out of these:

1. 6 →
2. 5 →
3. 8 →
4. 20 →
5. 14 →
6. 0 →



6. Garrits

All of these are garrits.

3 → 8
5 → 12
0 → 2
7 → 16
6 → 14
1 → 4

Make garrits out of these:

1. 4 →
2. 9 →
3. 100 →
4. 40 →
5. 31 →
6. 19 →

Answer Sheets for Success Problems

Mollywobbles:

Example:

1.Piniops:

1.
2.
3.
4.
5.
6.

Make your own Piniops:

What is the rule for Piniops?

____

Example:

2.Googologs:

1.
2.
3.
4.
5.
6.

Make Your own Googologs:

What is the rule for Googologs?

____

3.Willids

1.
2.
3.
4.
5.
6.

Make your own Willids:

What is the rule for Willids?

____

4. Callins

1.
2.
3.
4.
5.
6.

Make Your own Callins:

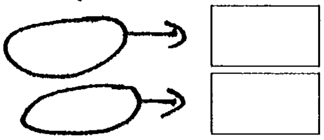
What is the rule for Callins?

____

5.Homins:

1.
2.
3.
4.
5.
6.

Make your own Homins:



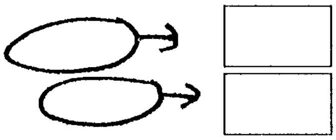
What is the rule for Homins?

____

6.Garrits:

1.
2.
3.
4.
5.
6.

Make Your own Garrits:



What is the rule for Garrits?

____

Failure Problems

3. Bovins

All of these are bovins.

14 → 4 25 → 10 50 → 0

75 → 35 111 → 1

Make bovins out of these:

1. 4 →
2. 19 →
3. 21 →
4. 232 →
5. 16 →
6. 80 →

4. Bigelons

All of these are bigelons.

10 → 110 5 → 30 3 → 12

1 → 2 8 → 72 0 → 0

Make bigelons out of these:

1. 2 →
2. 9 →
3. 4 →
4. 15 →
5. 6 →
6. 7 →

5. Manipens

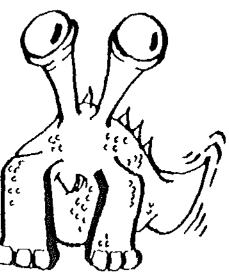
All of these are manipens.

3 → 8 5 → 14 1 → 2

20 → 59 14 → 41 10 → 29

Make manipens out of these:

1. 8 →
2. 2 →
3. 12 →
4. 19 →
5. 21 →
6. 4 →



6. Escams

All of these are escams.

3 → 4 9 → 64 4 → 9

5 → 16 21 → 400

Make escams out of these:

1. 6 →
2. 1 →
3. 10 →
4. 2 →
5. 12 →
6. 20 →

Answer Sheets for Failure Problems

PART ONE: Mollywobbles:

Example:

1.Piniops:

1.
2.
3.
4.
5.
6.

Make your own Piniops:

What is the rule for Piniops?

____

Example:

2.Googologs:

1.
2.
3.
4.
5.
6.

Make Your own Googologs:

What is the rule for Googologs?

____

3.Bovins

1.
2.
3.
4.
5.
6.

Make your own Bovins:

What is the rule for Bovins?

____

4. Bigelons

1.
2.
3.
4.
5.
6.

Make Your own Bigelons:

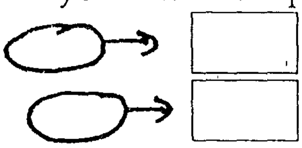
What is the rule for Bigelons?

____

5.Manipens:

1.
2.
3.
4.
5.
6.

Make your own Manipens:



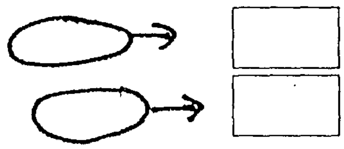
What is the rule for Manipens?

____

6.Escams:

1.
2.
3.
4.
5.
6.

Make Your own Escams:



What is the rule for Escams?

____

Answers to Examples for PC1 and PC2

Mollywobbles:

Example:
1. Piniops:

1. 24
2. 13
3. 88
4. 7
5. 10
6. 52

Example:
2. Googologs:

1. 30
2. 51
3. 15
4. 57
5. 60
6. 153

What is the rule for Piniops?

Subtract 4

What is the rule for Googologs?

Multiply by 3

Wollygoggles

Example one:
Jetabs:

1. E
2. F
3. J
4. I
5. G
6. H

Example Two:
Pinkaloes:

1. C
2. G
3. K
4. D
5. I
6. A

What is the rule for Jetabs?
Numbers that end in O
or Number that are divisible
by 10.

What is the rule for Pinkaloes?
Two of the numbers multiplied
together will give the third number.

Appendix 3: PC2 Problems

1. Examples
2. Problems
3. Answer Sheets

Examples

Wollygoggles

The problems below are called Wollygoggles. Wollygoggles are sets of numbers that are related by a rule.

e.g. 5, 10, 15, 20 and 25 are related because they can all be divided evenly by 5.

Some types of wollygoggles have rules like this (e.g Jetabs).

Others like pinkaloes have relationships between the 3 numbers in each box.

You have to figure out what the rule is that works for each set of Wollygoggles.

Turn to the Wollygoggle answer sheet in your booklet and begin.

Jetabs

Example one

All of these are jetabs.

10	790	340	0	20

None of these is a jetab.

145	33	11	402	75

Which of these are Jetabs?

1.	365 B	16 G	Both F	Neither E
2.	180 F	105 A	Both I	Neither C
3.	880 K	290 D	Both J	Neither L
4.	510 I	92 C	Both H	Neither A
5.	225 D	168 K	Both B	Neither G
6.	772 C	130 H	Both A	Neither K

Pinkaloes

Example two

All of these are pinkaloes.

4 8 2	10 7 70	132 11 12	9 36 4

None of these is a pinkaloe.

10 12 2	202 2 20	5 51 2505	23 12 11

Which of these are pinkaloes?

1.	11 143 13 C	9 6 53 K	Both A	Neither B
2.	7 40 7 I	10 110 11 J	Both G	Neither L
3.	8 74 9 D	7 6 191 F	Both E	Neither K
4.	14 1002 12 B	8 48 6 D	Both J	Neither H
5.	13 9 117 I	4 48 8 A	Both L	Neither B
6.	11 7 777 E	7 9 71 J	Both L	Neither A

Problems

1. Poddysnips

All of these are poddysnips.

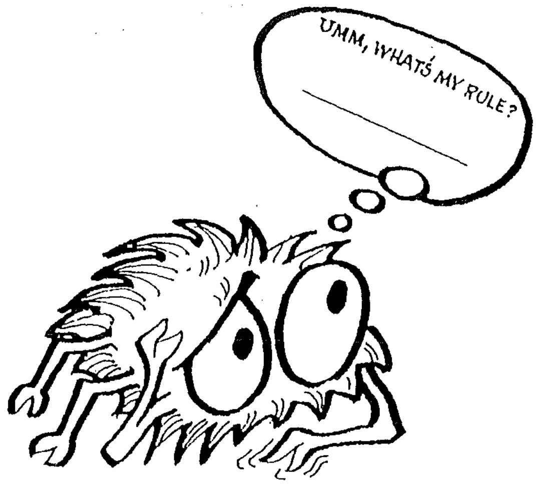
4	100	16	70	2

None of these is a poddysnip.

17	3	49	101	31

Which of these are poddysnips?

1.	48	152	Both	Neither
	J	L	F	B
2.	63	13	Both	Neither
	E	C	G	H
3.	82	176	Both	Neither
	A	I	K	D
4.	33	112	Both	Neither
	G	I	E	C
5.	198	99	Both	Neither
	A	L	J	B
6.	201	222	Both	Neither
	C	G	E	D



2. Lillamins

All of these are lillamins.

5	25	115	100	30

None of these is a lillamin.

3	22	16	171	31

Which of these are lillamins?

1.	45	88	Both	Neither
	L	B	J	E
2.	159	39	Both	Neither
	E	C	D	J
3.	225	14	Both	Neither
	D	B	C	E
4.	76	95	Both	Neither
	C	B	E	K
5.	35	55	Both	Neither
	E	G	C	H
6.	12	40	Both	Neither
	A	E	L	I

3. Snofrips

All of these are snofrips.

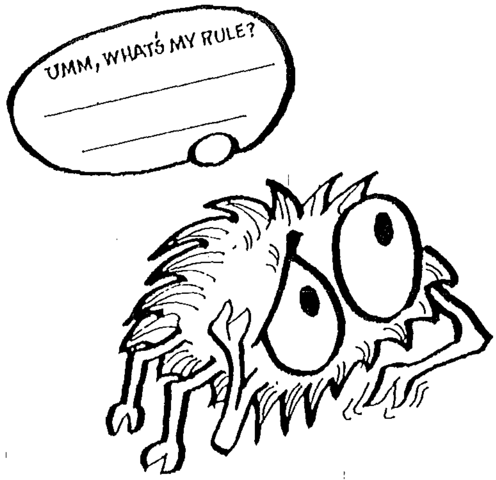
4 5 7	5 6 9	10 10 18	8 5 11	7 7 12	4 0 2

None of these is a snofrip.

4 1 2	4 3 12	8 1 18	5 5 23	6 6 6	3 7 10

Which of these are snofrips?

1.	14 10 22 K	9 8 14 H	Both B	Neither A
2.	7 9 13 C	13 9 20 I	Both F	Neither E
3.	15 15 30 J	19 25 5 D	Both G	Neither H
4.	8 9 3 C	3 2 4 B	Both A	Neither F
5.	4 4 6 L	14 20 8 E	Both B	Neither D
6.	8 16 8 J	17 25 11 L	Both G	Neither D



4. Boppets

All of these are boppets.

819	235	101	347	426	145	246

None of these is a boppet.

333	405	216	510	111	142	132

Which of these are boppets?

1.	304 A	617 C	Both F	Neither D
2.	909 I	516 G	Both C	Neither B
3.	437 B	336 A	Both H	Neither C
4.	374 E	945 I	Both D	Neither F
5.	283 A	607 E	Both I	Neither D
6.	224 H	125 E	Both G	Neither B

5. Possings

All of these are possings.

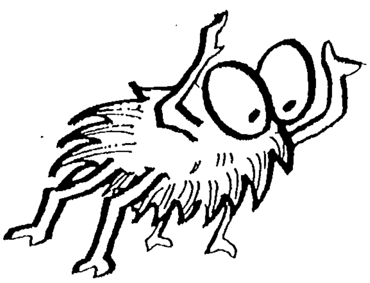
34	7	106	43	61

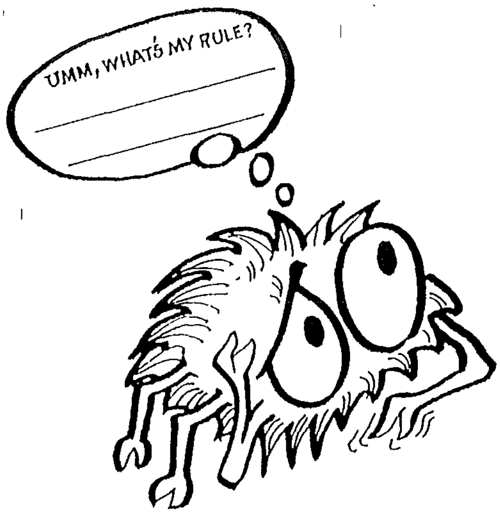
None of these is a possing.

104	5	30	405	51

Which of these are possings?

1.	70 (I)	241 (G)	Both (B)	Neither (L)
2.	133 (I)	16 (L)	Both (G)	Neither (F)
3.	520 (J)	232 (I)	Both (L)	Neither (F)
4.	207 (K)	81 (J)	Both (I)	Neither (F)
5.	511 (B)	520 (A)	Both (I)	Neither (J)
6.	63 (E)	622 (D)	Both (C)	Neither (J)





6. Tanips

All of these are tanips.

100	9	81	25	6400	625

None of these is a tanip.

35	10	99	48	120	1000

Which of these is a tanip?

1.	144 (I)	324 (H)	Both (J)	Neither (A)
2.	440 (I)	729 (K)	Both (F)	Neither (H)
3.	255 (I)	1296 (H)	Both (F)	Neither (A)
4.	899 (B)	1088 (I)	Both (A)	Neither (F)
5.	289 (E)	576 (D)	Both (A)	Neither (I)
6.	361 (L)	169 (C)	Both (I)	Neither (K)

Answer Sheet

Example one:
Jetabs:
1.
2.
3.
4.
5.
6.

Make your own Jetabs:

What is the rule for Jetabs?

____

Example Two
Pinkaloes:
1.
2.
3.
4.
5.
6.

Make Your own Pinkaloes:

What is the rule for Pinkaloes?

____

1.Poddysnips
1.
2.
3.
4.
5.
6.

Make your own Poddysnips:

What is the rule for Poddysnips?

____

2. Lillamins
1.
2.
3.
4.
5.
6.

Make Your own Lillamins:

What is the rule for Lillamins?

____

3. Possings:

1.
2.
3.
4.
5.
6.

Make your own Possings:

What is the rule for Possings?

____

4. Tanips:

1.
2.
3.
4.
5.
6.

Make Your own Tanips:

What is the rule for Tanips?

____

5. Snofrips:

1.
2.
3.
4.
5.
6.

Make your own Snofrips:

What is the rule for Snofrips?

____

6. Boppets:

1.
2.
3.
4.
5.
6.

Make Your own Boppets:

What is the rule for Boppets?

____

Appendix 4: PC3 Problems

1. Multi-choice Problems
2. Multi-choice Answer Sheet

Multi-choice Problems

Multi-choice

The following 10 questions are multi-choice. You may begin as soon as you are ready. Try your best to answer all the questions. If you get stuck on one question then go on to the next question. **Do not** write on the question sheet. Write your answers in the boxes provided on the answer sheet. You may use the bottom and the back of the answer sheet for any working.

1. Megan wants to buy a microwave oven costing $675. She can pay $60 per month for 1 year or the whole $675 now. How much does she save by paying now?

   A. $30
   B. $45
   C. $55
   D. $615
   E. $720

2. A scale-model tower is built so that it is one tenth of the original tower. If the original tower has a height of 90 metres, the scale models height will be

   A. 1 m
   B. 9 m
   C. 10 m
   D. 90 m
   E. 900 m

3. A taxi driver charges $1.50 per kilometre driven plus $2.00 per trip. Which equation **could** be used to find the cost of a 15 kilometre trip?

   A. (15 X $1.50) + 2.00 = ?
   B. 15 X ($2.00 + 1.50) = ?
   C. (15 X $2.00) + $1.50 = ?
   D. 15 X ($2.00 X 1.50) = ?
   E. 15 + ($2.00 + $1.50) = ?

4. A netball player was successful in 75% of the shots that she attempted in a game. She got 35 goals. Which sentence shows a way to find out how many shots she attempted?

   A. $\frac{75}{100} = \frac{35}{n}$

   B. $\frac{75}{100} = \frac{n}{35}$

   C. $\frac{35}{100} = \frac{n}{75}$

   D. $\frac{35}{75} = \frac{100}{n}$

   E. $\frac{35}{75} = \frac{n}{100}$

5. At a fishing competition 2 out of every 5 people given prizes were children. If 30 people were given prizes, how many children received prizes?

   A. 2
   B. 6
   C. 10
   D. 12
   E. 15

6. In a 400-metre race a runner took exactly 189 strides from start to finish. Which calculation **could** be used to find the length of each stride?

   A. 400 ÷ 153
   B. 189 ÷ 400
   C. 189 X 400
   D. 400 - 189
   E. None of these

7. If a square metre of carpet costs $9·00 Which of the following equations show how much carpet will be needed to cover the floor of two rooms, one 3.5 metres square and a second room 4.5 metres square?

   A. ($9.00 X 3.5) + 4.5
   B. $9.00 X 3.5 X 4.5
   C. $9.00 + (3.5 X 4.5)
   D. $9.00 ÷ (3.5 + 4.5)
   E. $9.00 X (3.5 + 4.5)

8. A bulldozer driver charges $8 per hour worked plus $20 per job. Which equation **could** be used to find the cost in dollars of a 5 hour job?

   A. 5 X (20 + 8)
   B. (5 X 20) + 8
   C. 5 X (20 + 8)
   D. 5 + (20 + 8)
   E. (5 X 8) + 20

9. A hamburger and 2 drinks cost $5
   2 hamburgers and 2 drinks cost $8
   How much does 1 drink cost?

   A. 80 cents
   B. $1
   C. $1·20
   D. $1·50
   E. $1·80

10. A theatre owner is to receive 25% of ticket sales from a concert. If the total ticket sales were $4 800, how much money will the theatre owner get?

   A. $1 200
   B. $1 500
   C. $2 3000
   D. $2 400
   E. $2 500

Multi-choice Answer Sheet

1.		6.	
2.		7.	
3.		8.	
4.		9.	
5.		10.	